Group SC B1 (Insulated Cables)

GROUP DISCUSSION MEETING SUMMARY

(Wednesday 27th August 2008)

Gunnar Evenset Special Reporter SC B1 (Insulated Cables)

The discussion meeting was chaired by Fredrik Rüter (SE), Chairman of SC B1.
Gunnar Evenset (NO) acted as Special Reporter and Yves Maugain (FR) as meeting Secretary.

The Chairman opened the meeting with a presentation of the present state of the Study Committee, addressing the actual fields of activities and the trends in the field of insulated cables.

The Special Reporter then made a short introduction of the Special Report, which was based on 22 papers submitted within Study Committee B1 to three Preferential Subjects earlier this year.

Based on these 22 papers the Special Reporter had prepared the Special Report with 11 questions, which for the Group Discussion Meeting had attracted 43 prepared contributions. 47 spontaneous contributions were made during the meeting.

More than 200 people attended the meeting during the morning session and approx. 270 in the afternoon session.

Preferential Subject N° 1: Technical challenges overcome in newly installed underground and submarine transmission systems.

- **Current state-of-the-art in design, testing of AC and DC, submarine and underground cable systems (including High Temperature Superconducting, HTS) and Gas Insulated Lines (GIL).**
- **Innovations in cable systems installation.**

This subject had attracted 7 papers for the Special Report, and 12 prepared contributions for the Group Discussion Meeting.

The first question addressed test procedures for HTS cables. The contributions discussed the complexity of testing the cables in the factory. Filling the cables with liquid nitrogen before testing may be theoretically possible, but there are associated risks with the very large thermal contraction of the cables and the time necessary for such testing would be long. Sample tests have been performed to monitor the quality of the cables produced until now.

However, the conclusion is that the test procedures can be further improved in the future as the technology becomes more mature.

Are the limits for land synthetic cables reached? The answer from the contributors was unanimously no! The dielectric strength of the commercially available compounds is very high, but can be further improved by focusing on contaminants. This may enable higher operating stresses and maybe even higher voltage levels could be used. The insulating compounds may also be improved to support production of cables with larger size conductors.

Efficient installation of cables is a big challenge to utilities and cable makers. Jointing is rather time consuming and the utilities aim to install as long continuous lengths as possible. Cable lengths of up to 2500m of 245 kV cables have been installed in tunnels in Japan.
More efficient installation can also be achieved by choosing slim cable designs resulting in longer drum lengths. However, the voltage level on the sheaths of cross bonded systems must be carefully considered when the installation lengths are increased.

Question four addressing the state of the art of submarine EHV cable systems using XLPE insulation attracted two contributions. The presentations showed that the first 245 kV and 420 kV submarine cable links are in service, but that there is still some development to be done on jointing techniques and development of test procedures.
Concern about verification of lead fatigue was raised during the discussion. The answer from the manufacturers was that this issue is taken seriously by the manufacturers and that verification testing has been performed.

Preferential Subject No.2: Current and future methods supporting efficient operation, maintenance and upgrading/replacement decisions of cable systems.

- **Maintenance policies.**
- **Diagnostic methods applied to Cable Systems.**
- **Remaining Life Assessment Methods**

This subject had attracted 4 papers for the Special Report, and 11 prepared contributions for the Group Discussion Meeting.

Question 1 addressed the ability of online PD monitoring techniques to distinguish internal partial discharges from noise and degradation mechanisms in the accessories. The question attracted 5 prepared contributions. The contributors expressed different views on the ability of the online PD measurements to distinguish between noise and internal discharges and there was also a discussion about the acceptance levels and sensitivity.
The general view after the discussion was that more knowledge is needed on this subject and that there is a need for some kind of standardisation of the test setup, etc.

Question 2 addressed the service experience of past and recent cable assets. The presentation started with an invited contribution from the convenor of WG B1-10 "Update on service experience on underground and submarine cable systems". The presentation showed the

results from the questionnaire that had been circulated by the group. A main conclusion from this investigation was that accessories on XLPE cables are the main concern and that quality control during jointing work must be focused.

The presentations also showed that there is ongoing work to increase the knowledge about degradation mechanisms to improve asset management.
It was also stressed that the service experience is closely connected to quality control during production in order to minimize the risk for internal failures.

The discussion highlighted that good statistics is needed and cooperation between utilities is necessary in order to compare links with similar designs.

Preferential Subject No.3: Future technical solutions for underground and submarine transmission systems addressing environmental and economical considerations.

- **Balancing environmental requirements against economy.**
- **Electromagnetic Fields (EMF) mitigation, restricted access, installation in tunnels, bridges and along motorways and railways.**
- **Development trends towards higher voltages and ratings.**

This subject had attracted 11 papers for the Special Report, and 20 prepared contributions for the Group Discussion Meeting.

The afternoon session started with an invited presentation related to question 1. Environmental impact of power transmission becomes more focused and the presentation showed examples on how design, manufacture and service life influences the CO_2 emission from the link. Thus, there are several factors that can be considered to reduce the CO_2 emission when planning new cable links.

The presentations also showed that utilities have plans to consider the environmental impact of new cable links.

The contributions to question 2 showed that there are good examples of correlation between measurements and calculations of the magnetic field when field reducing techniques have been used. The presentations also gave an overview on different methods that has been use to reduce the EMF from cable circuits. However, some of the mitigating methods are very difficult to install in practice.

HVDC extruded cables has been on the market for some years in combination with Voltage Source Converters and may in some cases be an attractive alternative to overhead lines. The contributors stressed that light weight cables together with prefabricated joints makes XLPE cables more competitive compared to mass-impregnated cables.

Question 4 addressed the experience with HV circuits in shared structures and fire protection of such tunnels. Such shared structures are widely used for example in Japan with good

experience while other countries are more reluctant to use shared structures because of complicated construction and operation conditions.
In case of fire there is some experience that one cannot rely on the fire brigade. Thus, fire fighting installations in the tunnels might be necessary. This was not discussed in detail.

There are a variety of designs on transition joints depending on voltage levels, cable designs, etc. In general the service experience with these joints is good. WG B1.24 "Test procedures for HV transition joints" is currently working on test recommendations for transition joints and aim to complete the work in 2009.

The special reporter made a brief summary of the discussion and the Chairman concluded the meeting by thanking the contributors for their high quality contributions and the audience for the fruitful discussion. He also thanked the special reporter and the secretary for preparations and organisation of the meeting.

DISCUSSION MEETING

Group B2
(Overhead Lines)

SUMMARY

(Tuesday 26th August 2008)

Chairman: Mr. Bernard DALLE
Technical Secretary: Mr. Normand BELL
Special Reporters: Mr. Pierre PRAMAYON (Preferential Subject 1 – Increasing capacity of overhead lines)
Mr. Gary BRENNAN (Preferential Subject 2 – Solutions to improve the availability of overhead lines)

INTRODUCTION

The SCB2 Chairman opened the meeting with a presentation of the present state of its Study Committees, addressing the actual fields of activities, administrative and technical strategies and future goals.

1. PREFERENTIAL SUBJECT 1 : P. PRAMAYON

Preferential subject 1 has explored the subject of increasing the capacity of transmission lines by maximizing the use of existing facilities while maintaining and improving service reliability. It has addressed all kind of improvement studies, projects or existing system upgrade realisations based on material changes or on innovative operational based methods. Willingly, the questions of PS1 were elaborated as to encourage contributions prepared either by Engineers/Designer/Manufacturers or by Planners/System Developers, all in the purpose of stimulating interactions between the two parties.

PS1 inspired 12 CIGRE articles, which were classified, in four sub-topics:

- High Temperature Low Sag Conductors and conductors of new types,
- Capacity increase by use of weather forecast, probability based rating methods or use of real time monitoring equipments,
- General papers on OHL capacity increase miscellaneous solutions, HSIL lines and questions of environmental impacts of line uprating,
- Conversion of AC lines into DC.

During the discussion group, 38 answers to the questions of PS1 were proposed through 33 oral presentations and each part was punctuated by a few spontaneous contributions. Such large number of contributors gave evidence that the subject was of importance through the transmission Network Community.

It must be noted from the number of contributions and the questions from the floor that the interest of SCB2 members specifically focused on:

1) Use of Real Time Monitoring systems and probabilistic rating methods based on actual meteorological parameters survey. The topic was highlighted by the presentation of some new and clever devices to measure lines parameters, some discussions on the way to install and operate the existing devices, some discussions on the actual use and acceptability of such means by operators, or even the impact on the equipment ageing while running the systems hotter.

2) DC technologies and the conversion of AC lines into DC systems. This topic, which is not, a new one seems to raise again as one of the most promising issues to upgrade existing systems capability, either by the means of converting existing AC circuits, or by the use of new links. This interest is reinforced by the progress made on converters, both on the technical and the economical aspects. Spontaneous contributions from the floor demonstrate that this topic of converting AC lines into DC is a very active one.

Among other topics of discussion, one must note High Surge Impedance Loading (HSIL) lines, an original technology extensively used in Brazil, the effect of a higher utilisation of the systems on environment (EM fields) or on equipment ageing, and finally some concerns on electrical aspects of DC links.
Surprisingly, the topic of High Temperature Low Sag Conductors was not an active one, even with the presently emerging technologies using composite core.

PREFERENTIAL SUBJECT 2 : SPECIAL REPORTER GARY BRENNAN

The preferential subject deals with various strategies to improve the reliability of overhead lines and explored three areas :

- maintenance & refurbishment methods based on diagnostic tools and methods;
- increasing reliability and security by improving electrical and mechanical performances: mechanical strength coordination, foundations assessment, de-icing methods, anti-cascading towers, mechanical fuses et al; and
- solutions for quick recovery: emergency structures, details of fault and emergency recovery plans; construction of temporary lines et al.

The contributors presented a comprehensive view of various strategies and activities being undertaken throughout the world to improve the availability of overhead lines.

These strategies range from real time monitoring of transmission lines to GIS modelling of faults and pollution mapping with correlation to component remaining life and hence line serviceability and or availability.

Contributors also discussed laboratory testing of conductors and insulators. Novel solutions were presented for conductor refurbishment, upgrading and uprating. Most importantly some contributors discussed the difficult and sometimes complex area of technical and equally important the economical triggers to undertake uprating and upgrading to ensure longer term availability of overhead lines.

Finally, four contributions discussed two utility's preparedness to respond to major transmission line faults and or emergencies. This was a delicate and sensitive subject to discuss preparedness to respond to failure. It was hopeful that this part of the sessions would have provided a unique

opportunity for more utilities to share their expertise experiences to respond to faults and emergencies.
Perhaps this leaves a moment for reflection that, if indeed utilities need to improve the availability of overhead lines then in part, there is a requirement for utilities to have the ability to respond to fault and emergencies in a timely and effective manner.

In summary the session dealt with current maintenance and refurbishment activities, dealt with the future by upgrading and uprating propositions and concluded by dealing with the emergency recovery strategies.

DISCUSSION MEETING

SUMMARY

GROUP B3

SUBSTATIONS

28th August 2008

In the last decade the changes in the Power Transmission and Distribution systems have been significant and are still continuing. The challenges remain still the same since years: To improve the technology and the equipment but also to increase its efficiency and to reduce the life cycle cost of the assets. All this in a quickly changing environment, which gets more and more importance, with aging components, which have to be maintained, retrofitted or replaced in the near future. This is not really new, but the problems are still not solved. And at least a decision has to be made.

A total of 24 papers addressing the two Preferential Subjects of 2008 have been selected for the 2008 session. These papers make significant efforts expended by the authors in producing these papers and are truly appreciated.

As a test we asked some authors to present in the session selected and important papers in a short and comprehensive summary of about 4 minutes, followed by the possibility to discuss them directly with the author. From the 15 chosen papers 12 authors were willing to present. Traditional we asked also questions about the contents of all received papers. As response to the questions of the special reporter we received in total 35 prepared contributions. We appreciate this interest and we try to allow every speaker round about 3 minutes for his contribution, enough to present a clear statement based on given facts and supported by impressing pictures.

Addressing Preferential Subject 1 **Lessons learned on Substation Asset Use Optimization** we received 8 papers to the asset management and maintenance strategies; only one paper addresses a failure case study of a circuit-breaker. The influences of dynamic loading of the equipment are obviously not of common interest, although they must have an impact on the assets.

Fundamental changes of the structure of transmission and distribution in the last years lead automatically to new ways of thinking, the even more aged equipment is a challenge for operators and strategies are needed to overcome these problems. Consequently most of the contributions refer to asset management planning, which includes substation maintenance as well as substation life cycle cost evaluations, all to optimize the asset management process of substations.

Practical experience will be shared with contributions about the consequences of a single phase fault of a circuit-breaker on the substation and about particular substation insulator maintenance in Iran.

The nine questions to the preferential subject 1 were related to all questions of life cycle management. One point of interest is the actual age of the substation equipment, its expected remaining life and how to handle this.

The whole range of substation equipment since the 60s is obviously still in service. We learned that even minimum oil circuit breakers still represent in some countries for HV levels of 72.5 and 100 kV about 40% of all HV breakers in service. The average age of the minimum oil circuit breakers is around 30 years and older breakers are reaching 45 years. Most of the utilities see their life prolonged on the network between 40 till 50 years; some others might earlier going to be replaced for technical, legal or economic reasons.

The maintenance strategy for aged equipment is mainly to maintain reliability and reduce maintenance cost. The maintenance is often done by the utilities itself. However it is considered to investigate in the cause of failures in cooperation with manufacturers as well as exchange of failure information among utilities. Especially the sharing of failure information among utilities is useful. In some countries already a user forum exists of equipment users, where experiences are shared and invited manufacturers are asked to comment. This may be an appropriate approach to overcome these problems.

One question was asking whether predicted or experienced reliability is regarded as more important for the user. According to statistical experience almost 50% of equipment failures are supposed to be not predictable, therefore the care about non predictable failures is very important. One answer: The calculated reliability performance of a system gives the expected values of the considered reliability indices – based on the applied stochastic model of component outages and related model parameters. These results are not influenced by individual stochastic events, as long as the input data are derived from an appropriate statistic.

The main application of such calculated expected reliability indices is therefore system planning – where the focus is not on a prediction of the actual reliability performance of a single year (which is, anyway, hardly possible at all), but on the evaluation and comparison of different system scenarios. In this task, indices as objective as possible are required – a requirement that is met by calculated indices much better than by historic indices, at least assuming suitable models and input data. However the individual condition of every utility has a major impact on the results.

Another approach in concerning equipment repair after a failure is the utility's technical department being responsible for controlling the extent of emergency spare parts held nationally. It is also responsible for studies into the benefit of producing new national emergency spare parts for this or that category of equipment. The technical department is also involved in managing the stock of equipment.

To illustrate the extent of the national reserve for GIS substations, it is useful to notice that stocks include parts necessary for each function (circuit breaker, support insulators, partitions, earthing switches, instrument transformer, busbars...). For each new generation of equipment installed on the network, items are sourced and then stored in addition to existing stocks.

If it isn't possible to predict failures the policy of a big utility consists in using internal specialists which are able to repair equipment in time frames which are compatible with operation requirements of the network. Specialist teams of the utility as well as of manufacturers are used. It would be interested if all these costs are collected in the life cycle costs of the equipment, and if so, conclusion were drawn out of this.

It is interesting to learn that repairing of SF6 circuit breakers which present too high SF6 leakage rates seems to be a big issue.

Modern HV equipment is reliable and requires less maintenance. Maintenance activities are more and more carried out condition based or as reliability centered maintenance. Condition based maintenance needs detailed knowledge of the equipment and the physical background. Normally these maintenance measures are performed by specialists, i. e. experienced and highly skilled personnel. In case of a large amount of different pieces of equipment and of different types this costs high expenditure for training of specialized personnel. To overcome this situation a new approach was introduced: Application of an "automated, user instructed and data based inspection and diagnosis system" (ADS).

For non standard equipment and under the assumption that the service experience is sufficient, the overhaul is considered to be an alternative to the replacement due to the experience of a big utility. Such measure were shown on example of 420kV circuit breaker with breaking short-circuit current of 80 kA. Thanks to overhaul, the expected overall life time of the circuit breaker will be prolonged from 35 up to 40 years. From the financial point of view, such extension is very welcome. From the technical point of view, as far the major weaknesses has been removed by overhaul, the only limitation of life time are the wear of the high current contacts and of the hydraulic drive. The good service experience of overhauled equipment indicates that the measure was successful. In other words, the overhaul is an alternative to replacement for non-standard equipment.

The factors determining the end of life were named as there are change of technical requirements, requirements from a regulatory body, Skilled workforce availability, Specific knowledge of equipment, environmental requirements, Political requirements. Not everything is based on age, as you can see.

When equipment replacement must be deferred the end of life is not a fixed point of age. It has to be considered that the service life extension program (overhaul) Can cost >30% of replacement, and last but not least an Increased risk has to be accepted

The experience of composite insulators is based on about half a million in the voltage range above 145 kV in service and the today's market is of more than 50.000 insulators per year. The yearly growth rate is typically between 10-20%.

Information, collected by WG A3-21 through a questionnaire from utilities worldwide, confirm the positive experience with composite insulator housing following several years of service exploitation on hundreds of components. The same is confirmed by several long term experiences in different test stations. This is one experience on housings, practical Japanese experience however indicates that both long-rod and hollow type silicone rubber composite insulators tend to accumulate more pollution than porcelain ones not only under industrial but also under coastal areas conditions. As you can see there is still of field of investigation and on discussions.

So far the report of PS1, now continued by the summary of PS2. **New Challenges in Substations.**

The presentation and discussions reflected the impact of future network concepts, including the ones of already existing substations. Connecting new renewable generation including on- and off-shore wind farms are getting more important regarding energy generating and as a consequence adjacent substations as well. The equipment used in offshore substation is not particularly special but the particular environment gives rise to layout challenges. Some specific demands and key issues to be considered for such off shore substations connections are erection of equipment, testing, repair and maintenance, access a.s.o., for primary and secondary substation equipment.

The expected growth and consumption of electrical energy and their consequences for substations in e.g. megacities and metropolitan areas were discussed and already realized solutions presented. Papers on the design of substation with least environmental impact were presented as well as innovative designs and layouts of substations to increase operational flexibility.

An Australian Paper described the positive results of a standardized substation concept considering fast growing energy demands from a utility point view. It underlines that the adopting of a "standard design" approach will reduce design time and variation.

A Japanese contribution show well the benefits for standardized substation from the user's point of view: Reduced Engineering time, procurement cost reduction, improvement of maintenance ability and failure management. These benefits were described more in detail with a GIS example. The approach shows as well the good cooperation between manufacturers and utilities in finding common solutions even in complete Substation layouts. However as a spontaneous contribution stated if each customer standardizes his substations this still means a lot of different solutions.

To meet the increasing energy demand and to meet the requirement regarding invisibility of substations, intelligent solutions have to be found. A Spanish paper gave good examples how to fulfill these requirements with state-of-the-art HV equipment. Further examples confirmed this and stated the flexible modular design of GIS.

Cost reduction in designing and constructing new AIS-substations as well as expansion and renovation of existing substations is a more and more import issue. The presented Technical Brochure Nr. 354 "Guideline to cost reduction of AIS" of B3 WG B3.15shows very well the possibilities achieving this goal. It assists in identifying benchmarked values and develops guidelines for effective and efficient design, construction and commissioning processes in order to minimize re-design, re-work, and multiple checks.

A contribution towards our questions referring to LCA studies and the importance of environmental characteristics show that redesigning of GIS equipment towards defined application features can contribute to the reduction of GWP.

One contribution showed very well the importance of early stage planning of new substation solutions with a feasibility study. However especially in cases like off-shore wind farm connections among each other and to the land in the North Sea, where very little experience is available.

The presentation of CIGRE Brochure No. 351 "Application of Long High Capacity Gas Insulted Lines in Structures" gives an overview on all areas regarding these specific GIL applications. The paper comes to the conclusion that GIL is a practical opportunity to solve the need of High Power Transmission.

In the past production and consumption of electrical energy was a local business with limited energy transportation across borders. The deregulation of the energy market is nowadays the driver for long distance transports of high currents at extra high voltage. CO_2 taxation will force energy generation to renewable energies in general, which leads to more wind farms and transmission solutions in particular. GIL is, due to its technical behavior, e.g. minimum capacitive load, also an option to connect offshore wind farms. A second example of for GIL application is hydro power transmission due to the security of supply and the accessibility of the transmission tunnel under normal operating conditions. It seems that the demands regarding GIL-solutions are increasing as new applications in Germany and China show.

Increasing power demand and aging equipment require retrofit of substations. The main aspects which have to be considered for any retrofit concept are: safety, reliability and availability, flexibility and compatibility, footprint, investment and life cycle costs.

Advantages when using MTS are stated: replacement and therefore shut-down time are reduced to a minimum, because pre-fabricated and pre-tested modules arrive on site and need minimum installation efforts. Civil work is significantly reduced and can be performed while the existing substation is in service. Due to less space requirements more bays can be installed or the remaining space can be used for other purposes. A contribution from Ireland summarized the positive aspects on MTS as well.

Further contributions on substation designs for the least environmental impact give an interesting overview of what can be done, in particular in a common approach between supplier and user, to meet the growing environmental requirements.

The demand of wind power is expected to increase in Italy of some 25% in the next 4 years.

A new concept proposed a standardized direct connection of wind farms to the transmission network. The preferred solution is considering the economical aspect of the hybrid solution respectively named Mixed Technology switchgear. A contribution from Ireland states that two of the proposed substation layouts are used in Ireland as well. However, in these applications developers have opted for an AIS solution, MTS might be considered in case of space limitation. That means the decision depends on the individual parameters.

Data security of substation network infrastructures is an important issue. One contribution supported that, and gives organizational and technological examples for the operation of substations in order to overcome this situation.

In order to achieve higher reliability and shorter restoration time, substation automatic restoration systems are invented and they are installed in AIS-substations. The content one contribution describes a case solution of bus bar faults in EHV-substations. For the fault evaluation optical CT's and arc Industrial Television cameras are applied. Optical CT's are applied at busbar disconnectors to judge whether branch buses are healthy or not. The arc Industrial TVs detects arc light which occurs on busbars. For distribution substations, faults cause outage of customers because they directly supply electricity to them. Here optical CT's are applied to primary busbar disconnectors in order to detect the fault location. Field experiences and simulation results in this paper prove that automatic restoration can be achieved 80% faster than manned operation.

Another contribution shows that there is a standardized condition monitoring system for GIS available. These data con be the input for further use and evaluation of operational issues.

The consequences and measures for substations regarding electromagnetic field affects were touched. As a final item information about the impact and experience of substation data security in connection with IEC standards and time synchronization of substations were shared. Papers show that electrical field exposure regarding human safety aspects, reach significant leveling in HV AIS switchyards. The conclusion is that standard measures will lead to more safety of service staff working there. EMC is even considered in UHV substation designs as another contribution presented.

A special application of GPS based time synchronization and distribution system has sufficient accuracy and receiving stability as a paper explained. However the GPS systems have been used mainly for monitoring and analysis purposes to date and have not yet been applied to critical systems such as protection relay systems.

Appendix 1: Summary by the Special Reporter

DISCUSSION MEETING

for

SC B4, Cigre 2008 session

SUMMARY

GROUP B4
HVDC AND POWER ELECTRONICS

29th August 2008

Chairman : **Marcio Szechtmann** Secretary : **Bill Long**
Special Reporters: **Dr. Yanny Fu** and **Narinder Dhaliwal**

The chairman opened the meeting with introduction of the Working Group B4 structure.

The Guest speaker Mr. Stig Nilsson reviewed the history of FACTS technology.

The session was attended by about 250 delegates. 30 papers were covered by Study Committee B4. The discussion included 64 prepared contributions and 23 spontaneous contributions, thus reflecting the actuality of the preferential subjects and the large interest for the area of HVDC and Power Electronics.

The Mission of SC B4 is "To facilitate and promote the progress of engineering and the international exchange of information and knowledge in the field of HVDC and power electronics. To add value to this information and knowledge by synthesising state-of-the-art practices and developing recommendations". The scope of B4 addresses all the relevant target groups in the power industry interested in power electronics. Economic and environmental subjects of this technology are also covered.

Three preferential subjects were covered in the Technical Session:

1 HVDC transmission projects including applications at 800 kV

- Operational Performance of existing HVDC projects, Upgrading/replacement of older projects and application of Reliability Centred Maintenance in HVDC system design;
- Feasibility studies of new HVDC projects;
- Planning, Design and Reliability criteria and characteristics of new HVDC projects, also including considerations on overload capabilities and market aspects ;
- Issues and experiences with ground return and ground electrodes;
- New development such +/- 800 kV HVDC and VSC based HVDC projects;

2 **FACTS applications and new developments**

- Feasibility studies;
- Operational Performance and system impact of existing projects;
- New FACTS projects;

3 **New power electronic equipment development and applications**

- New development on power electronic devices;
- Applications in distribution systems;
- Applications in wind power;
- Applications in DC Grids for Urban applications.

PS 1: HVDC transmission projects including applications at 800 kV

There were 19 regular papers submitted under this subject. The breakdown of the papers was as following;

• Performance/upgrading of old projects	6
• Feasibility studies of new projects	3
• Planning design of new projects	4
• Ground electrodes	1
• 800 kV systems	4

In addition to the above, one invited paper on HVDC Performance from AG B4-04 was also submitted.

There were 13 special reporter's questions discussed by 53 prepared contributions and 12 spontaneous contributions. As a result the following can be concluded:

Numbers of older HVDC projects are approaching the end of their life and the utilities are investigating various methods of replacing the old equipment and in some cases upgrading the capacity at the same time. Loss of knowledge due to retirement of experienced staff is also a concern for some of these projects. The analogue controls are being replaced with digital controls to improve reliability. The digital controls provide greater flexibility for changes and provide additional functions of on-line monitoring.

The thyristor failure rate is very low in general however some projects are replacing thyristor valves and controls to improve the reliability. Regarding to digital controls, it was recommended that users must train their staff to be able to manage the software. In addition it was recommended that users should buy enough spares to last for the expected life time of the controls (25 years), at the beginning of the project.

Results of feasibility studies for interconnecting EU with North Africa, potential HVDC links in South African Power Pool and for developing hydro electrical potential of Madeira River in Brazil, were presented. Two bipoles rated at 3000MW

at +/-600 kV were selected to transmit 6000MW of power from Madeira River to loads centres 2500 km away for reliability reasons.

One paper described the application of Reliability Centered Maintenance (RCM) techniques to the HVDC converter stations resulting in 3% increase in availability. The HVDC performance survey continues to show that converter transformer failures are major contributor to the system unavailability. However the new projects are minimizing the outage time by having available spares at site and designing the switchyard for quick change of the transformers. JWG A2/B4-28 has prepared a design review guide specifically applicable to the converter transformers. The application of on-line condition monitoring system is becoming a routine on converter transformers. The transformer failure survey conducted for years 2005 and 2006 has shown the condition monitoring systems have helped prevent number of potential transformer failures. Some projects have built transformer repair shops on site in order to reduce the outage time.

There has been a substantial reduction in the VSC converter losses, the losses are now less than two times higher than the LCC converter, with a potential for further reduction. The foot print for a comparable size VSC converter is only 50% of that for LCC converter. The application of VSC technology to transmission of power is increasing. An overhead VSC based project has been planned in Africa. With the latest technological developments, VSC is likely to become the technology of choice up to 1000 MW in near future.

The design of earth electrodes and finding a suitable location for the electrode continues to be a challenge. Some cable projects have chosen to operate with metallic return in order to minimize the environmental concerns related to earth return.

The cable systems are now using real time cable load prediction systems to take advantage of the ambient conditions. The load calculation is performed using the dc current, the ambient temperature at the surface and the cable temperature. The loading limit is fed into the controls and the limit is applied automatically.

UHVDC systems at +/-800kV are scheduled to be in service in next 2-3 years both in China and India. The R&D needs for the +/-800kV equipment have been identified and testing facilities are now available. Outdoor insulation coordination and the design of valve winding bushing at the +/- 800kV level appears to be the biggest challenge. The level of pollution, the altitude of the station and the transportation limits are the influencing factors on the transformer design.

At present there are no standards for artificial pollution tests for the composite insulators. The software for calculating field distribution is available in 2D or 3D dimensions. For some cases (like bushing) it is not necessary to use 3D calculations as the object is rotating symmetrical.

It was demonstrated that the Multi Infeed Interaction Factor (MIIF) as suggested by WGB4-41 gives a good indication of the interaction between the various inverter stations. The studies should include the detailed representation of the controls and the controls should be coordinated to help the recovery of the converters.

PS 2: Facts applications and new developments

There were four papers submitted under this subject. Two papers were related to the performance of Static Var Compensators. One paper described application of asynchronized rotating compensator. Another paper described the application of STATCOM as dynamic energy storage device.

There were 5 prepared contributions and 2 spontaneous contributions at this session.

One paper described operational experience of 30 years with SVC's in Australia.
This paper is of great importance to the Power Electronic field, since it provides a comprehensive report on many different causes and consequences of SVC equipment failures. Although being a relatively simple sub-system, according to Paper 201, an impressive record of failures on SVCs has been reported, this for sure will help other users in the world to manage their maintenance policies.

One contribution also described failures of SVC's in detail. The failures seem to include all parts of the SVC's. The recommendations are a need to improve the specification as well as to incorporate Reliability Centred Maintenance (RCM) at the design stage. Improved communication between the suppliers and the owners is also recommended.

The paper from Russia described proposal to install asynchronized rotating compensators. The added advantage of these devices is that they provide inertia to the system as well as the ability to control voltage.

The SVC's are still the preferred solution for power systems as they have lower power losses, high speed response and require less maintenance.

A new concept for providing system stability by injecting real and reactive power using a STATCOM was presented. However more research is required for developing a suitable energy storage device.

PS 3: New developments in power electronics devices

There were total of seven papers submitted under this subject. Four papers were related to the integration of wind farms into the grid. One paper described the development of voltage divider for 800 kV systems. One paper described application of power electronic devices in the distribution system. Another paper described new Multilevel Voltage Sourced Converter Topology for HVDC application.

There were 6 prepared contributions and 2 spontaneous contributions at this session.

The new Multilevel Voltage Sourced Converter Topology is very promising development for long distance overhead transmission and for +/- 500 kV level. To restore the power in case of a DC line fault, the AC circuit breakers have to be opened in order to clear the fault on the overhead line. There is nearly no discharge of the submodule capacitors during such an event, because the IGBTs can be turned off within microseconds and the fault current rise is limited by the converter reactors. After a re-closure of the AC circuit breaker, the converter can be immediately deblocked in order to ramp up the voltage and the DC power.

Four papers described the integration of wind farms to the grid. In each case different technology was selected. For large wind farms LCC HVDC system still appears to be a competitive alternative. The size of the wind farm and the configuration plays an important part in the selection of the technology used for integration.

It was pointed out that in evaluation of the cost of losses the utilization factor must be taken into account.

Session Closing Remarks by SC B4 Chairman

The Chairman of SC B4 summarized the discussion into 13 main topics and thanked all contributors and attendants for valuable contributions and their interest in the session.

Dr. Bjarne Andersen is the new Chariman of the study committee B4 and Mr. M. Zavahir is the new secretary of the study committee B4.

Conclusions

Overall the sessions were well attended and the discussions were timely.

The prepared contributions generated a lot of spontaneous contributions, leading to a healthy technical session.

There is an increasing scope for HVDC applications with the demand for high power long distance transmission from fast developing countries.

The challenges facing the HVDC community are both from equipment and system performance issues. The community is learning to cope with the increasing demands placed on it due to resolving transformer failures and the need to implement UHVDC solutions. Cigre is playing an important role in all these aspects and is helping the HVDC and Power Electronics applications to improve overall power system performance from environmental, technical and economical aspects.

Recommendation

It would be better to have technical sessions of SC C4 and C6 not on the same day as for SC B4 due to close related subjects of insulation coordination and application of power electronics in dispersed generation causing conflict of session attending for broader audience.

DISCUSSION MEETING

SUMMARY

GROUP B5

PROTECTION AND AUTOMATION

27 August 2008

1. Overview of Proceedings

The day's discussions were opened with a short presentation on the mission of SC B5 and its current activities by the outgoing SC Chairman, Ivan De Mesmaeker (CH).

At of the start of each of the two technical discussion sessions, the Special Reporters for each Preferential Subject provided a presentation of their paper review reports and the questions they had raised to promote discussion. The power-point presentations of prepared contributions that had been received in advance of the Paris Session commenced. For both discussion sessions, there was also a period of 10-15 minutes where spontaneous contributions were made. The Special Reporters then made their power-point presentations to summarise the prepared and spontaneous contributions that had been made.

The concurrent attendance during the day peaked to an estimated 350-400 people.

The following brief summaries of each discussion session are based on the Special Reporter conclusions in power-point closing summary slides

2. Summaries for Each Discussion Session

PS1 - Impact of IEC 61850-9-2 process bus on protection and substation automation systems

Special Reporter - Christoph Brunner (CH)

Total prepared contributions = 39

- Implementations - there is no report available yet about any substation having been engineered with a fully process bus based architecture – however, significant progress in process bus development and acceptance has been achieved

- System architecture – different approaches exist to addres the availability of process bus based solutions: To switch or not to switch – that is the question!
- Time synchronisation – solved to some degree of satisfaction; integration of a solution using the communication network maybe in the future
- Testing concepts are in preparation – work required to benefit from the features of IEC 61850 maintaining interoperability
- Interoperability is still an issue – maybe more work is required to prepare agreements that limit the variations possible in IEC 61850
- The integration of software modules from multiple vendors may be required for future work on standardisation.

PS2 - Life Cycle Management of Protection and Control Systems

Special Reporter - Iony Patriota de Siqueira (BR)

Total prepared contributions = 48

Trends:

- Software plays an increasing role within Protection & Control Systems
- IED virtualisation & distribution of is under course
- Standardisation of hardware is a possibility
- There is currently an apparent lack of adequate tools to manage software assets.

Needs:

- Tools for managing software-based Protection & Control Systems:
    - models, versions, configurations, …
- Tools for managing user requirements:
    - specification and automated testing
- Tools for distributed Protection & Control Systems
    - remote access, security and grid operator rules

3. Closure

During the closing minutes, the outgoing SC Chairman - Ivan De Mesmaeker (CH) introduced the incoming SC B5 Chairman – Javier Amantegui (ES) and also the new SC Secretary - Iony Patriota de Siqueira (BR), who will replace the outgoing SC Secretary - Paul Hindle (UK)